

NEW BEDFORD HARBOR PILOT PROJECT

PRE-OPERATIONAL PHASE:

AMBIENT WATER QUALITY

CONDITIONS

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INTRODUCTION

Polychlorinated biphenyl (PCB) contamination in New Bedford Harbor was first documented by both academic researchers and the Federal Government between the years 1974 - 1976. Since the initial survey of the New Bedford area, a much better understanding of the extent of PCB contamination has been gained. The entire area north of the Hurricane Barrier, an area of 985 acres, is underlain by sediments containing elevated levels of PCB's and heavy metals including copper, chromium, zinc and lead. PCB concentrations range from a few parts per million (ppm) to over 30,000 ppm. Portions of western Buzzards Bay sediments are also contaminated, with concentrations occasionally exceeding 50 ppm. The water column in New Bedford Harbor has been measured to contain PCB's in the parts per billion range.

In August 1984 the Environmental Protection Agency (EPA) published a Feasibility Study of Remedial Action Alternatives for the upper Achusnet River Estuary above the Coggeshall Street Bridge. Sediments from this area of the New Bedford Harbor Superfund Project contain much greater PCB concentrations than the remainder of the harbor. The study proposed five alternatives for cleanup of the contaminated sediment. Four of biological monitoring that was conducted as part of the preoperational these alternatives dealt specifically with dredging the estuary to remove the contaminated bottom sediments.

Comments EPA received by on these dredging and disposal alternatives prompted them to ask the U.S. Army Corps of Engineers to perform additional studies to better evaluate the engineering feasibility of dredging as a clean up alternative. A pilot study of dredging and dredged material disposal alternatives was proposed to support this engineering feasibility

study. This study is a small scale field test of several dredging and disposal techniques to be carried out on site between March 1988 and June 1988. The need for such a study is particularly great at New Bedford due to our limited knowledge and experience in dredging and disposing of such highly contaminated sediment and where the data base for the impact of site specific factors on design is not available. The study will evaluate three types of hydraulic dredges with the contaminated sediment being placed in two separate disposal sites.

A monitoring program was designed by personnel from the Corps of Engineers Waterways Experiment Station and EPA's Environmental Research Laboratory in Narragansett, Rhode Island (ERLN). The objective of the monitoring program is to provide information that can be used to (1) evaluate the effectiveness of the dredging and disposal techniques employed, (2) predict the magnitude and areal extent of water quality impacts during a full-scale operation, (3) select optimum monitoring protocols, and (4) regulate pilot study operations. Results of this program will be used to evaluate the risks and potential benefits of a full-scale dredging and disposal operation relative to other proposed options for decreasing the contamination effects of PCBs and metals in New Bedford Harbor. The full details of the pilot study objectives, dredging and disposal operations, and the monitoring program may be found in Otis (1987).

This reports summarizes the results of the physical, chemical and biological monitoring that was conducted as part of the pre-operational phase. These data were collected to provide environmental baseline on water quality conditions and to further refine the design of monitoring techniques to be used during the dredging and disposal operations. The

physical data presented here include currents, tides, temperature, salinity and suspended solids measurements, with a primary focus on conditions at the Coggeshall St. Bridge. Receiving water toxicity was evaluated using four test methods: Arbacia sperm cell fertilization, the red algae, Champia and Laminaria reproduction, Cyprinodon growth and survival, and Mysidopsis growth and reproduction. The mussel, Mytilus edulis, was also deployed and its physiological health, growth and survival were evaluated. Finally, water column measurements were conducted for PCBs, cadmium (Cd), copper (Cu) and lead (Pb).

Also included in this report is a description of how the data acquired through the monitoring program will be used to determine if pilot study operations are causing an unacceptable risk to public health or the environment that will necessitate a modification in operating procedures or a termination of the project.

METHODS

FIELD SAMPLING METHODS

Water samples were collected, using hand-operated pumps, at four stations in New Bedford Harbor during two periods, July 8-14 and September 22-28, 1987, during the preoperational phase of the New Bedford Harbor Project. At Stations 1, 3, & 4 these samples were composites of samples taken from just below the surface, at mid-depth, and at 1 meter above the bottom (2 liters each) collected hourly during the daylight hours, except for the hour of high and low tides. Water was collected at only two depths at Station 1 during the lower half of the tide when the water depth was less than 2 meters. The five ebb tide samples were then composited as were the flood tide samples. This process was repeated for seven consecutive

days.

In addition, on 9/24, individual water samples, taken at Station 2 at 3 hours after high and low tides at 3 depths, both east and west of the channel (12 samples total), were examined for spatial variability. Likewise on 9/28, each of the individual hourly samples at Station 2 (10 total) were examined for temporal variability. Control water samples for the toxicity tests were collected from near West Island in Buzzards Bay and in Narragansett Bay.

The following table (Table 1) shows the sampling dates and the corresponding analyses that were performed. The daily ebb and flood tide water samples were used in the seven day static renewal bioassays on Cyprinodon and Mysidopsis. Individual tests using the individual daily water samples were performed on the remaining species. Water collected from control sites in Buzzards Bay and Narragansett Bay was used for comparison.

Whole water samples were collected at station NBH-2 (Coggeshall St. Bridge) for chemical analyses. Sampling occurred at two cross-stream locations, denoted "East" and "West". These locations were approximately one-third and two-thirds of the distance from the east to west banks of the channel under the south side of the bridge. At each location, 3 depths were sampled. During the first pre-operational phase, the "surface" sample was collected 0.6 meters below the water surface. A "bottom" sample was collected 0.6 meters above the bottom of the channel. A "mid-depth" sample was collected at a depth equal to one-half of the total water depth.

During the second pre-operational phase, the "surface" sample was collected 0.5 meters below the water surface, and the "bottom" sample was collected 1.0 meter above the bottom of the channel. The "mid-depth"

sample was still collected at a depth equal to one-half of the total water depth. Water depth was determined from the difference in distance between bridge to channel bottom and bridge to water surface. A weighted tape measure was used. This data was also used to determine the variation in tidal height over time.

Current speed data was used to determine the volume of sample collected at each sample location that was incorporated into the station's composite sample. This sampling methodology is referred to as "flow-proportional" sampling.

The formula used for sample volume (VKsL) determination is as follows;

$$VKsL = FKsL / FKtL \times 6000$$

where FKsL and FKtL are the flow rates (cm secL-1K) at the sample location and the sum total of flow rates at all sampling locations, respectively. The desired volume of the composited sample was 6000 ml.

In sampling activities of the first pre-operational phase, current meter measurements were made on 7/8, 7/9 and 7/13/87. An acoustic current meter (Neil Brown DRMC) was used. This instrument was also equipped with temperature and salinity probes. Samples were composited on these dates using flow-proportional sampling methods. Samples collected for toxicity testing were similarly composited during the intervening days (7/10-7/12/87) using current measurements made on 7/9/87.

In sampling activities of the second pre-operational phase, current meter measurements were made on 9/24 and 9/28/87. An electromagnetic current meter (InterOceans S-4) was used. This instrument was also equipped with temperature and salinity probes. Samples were composited on these dates according to the flow-proportional method. Samples for toxicity

testing were not composited during intervening days (9/25-9/27/87). Instead, equal sample volumes were collected at each location (i.e. 1000 ml) for compositing.

LABORATORY METHODS

[References to methods to be inserted later]

MUSSEL SCOPE FOR GROWTH AND TISSUE RESIDUE

The caged mussel is being used in the New Bedford Harbor Pilot Project as a biomonitor for potential chronic and acute effects that may be associated with dredging activities during the operational phases of the program. Mussels are being used also as chemical sentinels to measure increased availability of PCB's and some metals. The unique aspects of this biomonitoring tool are that the mussels are continually exposed to both the dissolved and particulate fractions of chemical compounds that may be entrained in the water column during periods of deployment. An objective of these pre-operational studies is to assess the appropriateness of mussel biomonitoring for application to problems that are specific to this site during the operational phases of the proposed dredging and diking activities. Criteria for suitability focus on sensitivity of the responses and the variability demonstrated among stations during the pre-operational studies. Sensitivity and variability of the methods are important to establish for verification and subsequent application of data in support of the proposed Decision Criteria. Scope for Growth (SFG), a measure of the amount of energy an animal has for growth and reproduction, is used as part of an index of the physiological condition of the mussel. Low scope for growth values have been demonstrated to be indicative of reduced growth, and impaired reproductive capacity. The

scope for growth and growth analyses protocols are presented in Nelson (1987). In addition to the fact that they are exposed continually to both the dissolved and particulate fractions of chemical compounds that may be entrained in the water column during periods of deployment, as mentioned above, analyses of mussel tissues provide a direct demonstration of those compounds that are biologically available for concentration from the water column by these sentinel organisms.

RESULTS

METEOROLOGICAL CONDITIONS

July, considered to be a dry month, had only 0.01" of rain during the sampling period. The weather was mostly warm and humid with an overnight low temperature of 64°F on July 8 and a daytime high of 90°F on July 10 (Table 2). September, on the other hand, was much wetter overall but still had only .03" of rain during the sampling period. There was, however, a significant rainfall during the preceeding week. Temperatures ranged from 46 F on September to 77°F on September 24.

PHYSICAL MEASUREMENTS

Temperature, Salinity, Currents, Tides

During the first pre-operational phase, temperature varied between 21.5 and 23.5 LoKC. During the second pre-operational phase, temperature varied between 18.5 and 19.5°. Profiles of temperature for each of the 5 sampling periods on the flood and ebb tides were generally similar over depth and between east and west locations. Although only minor differences ($< 0.5-1.0^\circ$) were observed, they are probably real, since the each data point represented the cumulative mean of the large number

of determinations ($n = 120$).

During the first pre-operational phase, salinity varied between 24 and 29 ppt. During the second pre-operational phase, salinity varied between 29 and 33 ppt. The relatively lower salinities observed during the first pre-operational phase cannot be explained by data on rainfall. Profiles of salinity for each of the 5 sampling periods on the flood and ebb tides were generally similar over depth and between east and west locations. Although only minor differences ($< 1-2$ ppt) were observed, they again are probably real, given the large number of determinations ($n = 120$) used to determine each data point. Salinity tended to be lower in surface waters and on the ebb tide.

During the first pre-operational phase, current speeds varied between 0 and 50 cm/sec. During the second pre-operational phase, current speeds varied between 0 and 90 cm/sec. The reason for the relatively lower current speeds observed during the first pre-operational phase are not clear at this time. Profiles of current speed for each of the five sampling periods on the flood and ebb tides were generally uniform over depth with only minor differences (5-10 cm/sec) being observed. Significant (2-fold) variations in current speed were often observed between east and west sampling locations.

The pattern of water depth in the channel over time was used to determine tidal variation. Tidal height on all dates was about 1.6 meters. This estimate was conservative since water depth was not measured during slack tide periods. In addition, windy conditions often impeded accurate measurements. More accurate tides data would require the deployment of tide gauges.

The results of physical measurements during the two pre-operational phases suggest that the variables of interest were fairly constant over depth. However, significant differences were observed between east and west sampling locations. Differences observed between east and west locations may indicate cross channel differences in water mass. It is not known whether these differences are time or spatially dependent, since available instrumentation would not allow synoptic measurements. Instead, a delay of 20-25 minutes between sampling activities between locations was necessary. The acquisition of new instrumentation under the Inter-agency agreement will allow this problem to be resolved.

Suspended solids

A summary of the suspended solids concentrations at the four sampling stations in New Bedford Harbor is shown in Table 3. Mean suspended solids concentrations range from a low of 4.4 mg/l to a high of 15.0 mg/l over the whole study site. Within station ranges, however, are not as great. At Station 1, values range from 5.6 to 8.6 mg/l, at Station 2, from 6.4 to 10.2. The greatest variability was present at Station 3 where values ranged from 6.1 to 15.0. Station 4 concentrations range from 4.4 to 7.9. At only one Station, Station 3, are the differences twofold or greater.

Since the data have not been subjected to statistical analysis, no definitive statements can be made regarding suspended solids distribution. There is a trend in the data, however, suggesting the ebb concentrations may be lower than those during the flood tide, especially during the dry period sampling in July. Concentrations tended to be more similar during the September wet period sampling.

There do not appear to be any trends in the hourly samples at any of the stations (Scott, 1987), nor did there appear to be any station differences. Station 4 does tend to exhibit the lowest values, however. The sampling to determine the degree of spatial variability at Station 2, also revealed no apparent trends.

BIOLOGICAL MEASUREMENTS

Receiving Water Tests

Arbacia (Sperm Cell Test):

In July, no toxic effects were observed. In September, moderate toxicity was noted on one day (9/22) for the Station 1 flood and Station 2 ebb samples (Table 4). Since this toxicity was marginal and not repeated after the first day of testing, it is not considered environmentally significant. No other toxicity was observed, including no significant spatial or temporal variation among individually examined samples at Station 2.

Champia reproduction:

The results were marginally acceptable due to problems in quality of stock cultures during the July sampling. In September, difficulty was experienced with the quality of the Narragansett Bay control water samples; hence, only site control water was used for comparison. The tests on samples collected on two days (9/24 and 9/28) were successful and showed significant degrees of toxicity at several stations, especially Station 3 (Table 5). This data does not correlate well with the observed trend of decreasing PCB concentrations in the water from Station 1 to Station 4 (ref: Chemical Analysis Progress Report -December 1987); however, it does correlate with the available copper data (Station 2)

which is sufficiently high to cause such effects.

Laminaria reproduction:

No toxicity was observed in July; however, results were lowest for the Narragansett Bay control sample indicating a possible stimulatory effect at New Bedford Harbor samples (Table 6). Due to excessive variability among replicates in September, the results of this test were not considered to be valid.

Cyprinodon growth and survival:

No toxic effects were observed for any sample set in July, however, the survival of the control animals was unacceptably low.

Mysidopsis growth and reproduction:

No differences with respect to growth (weight gain) were observed in July; however, significant mortality was observed at Station 2, and egg production was below acceptable levels in the control samples.

Tests were not conducted in September.

Mussel Scope for Growth

Mussels were collected from a reference population, appropriately characterized chemically (see Section ____, Appendix ---.) and deployed at Stations 2, 3, 4, 5(or 6) (Figure ____ note: a figure will be provided), at two time intervals, June 5 - July 7 and September 14 - October 10, 1987. Temperature ranged between 17 and 22°C during both exposures, except during the latter part the September-October period when temperatures dropped to between 13 and 14°C. During both exposure periods dissolved oxygen and salinity remained nearly constant among stations and between sampling times.

During the first time interval, SFG demonstrated an inverse

relationship with PCB levels in the water column. There were significant differences among stations in SFG after seven days. The SFG pattern observed after the seven day exposure was repeated at the twenty eight day collection time, indicating the seven day results were predictive of what would be expected at day twenty eight. Significant differences among stations in shell growth after 28 days of exposure were inversely correlated with PCB tissue concentrations. Response patterns shown by SFG after seven days and shell growth after twenty days were very similar. In that sense, the seven day SFG results were predictive of the twenty eight day shell growth data. SFG and shell growth were lowest and the PCB levels highest (in the water column as well as mussel tissue) at the Coggeshall Street Bridge. SFG and shell growth were highest and PCB levels lowest (in the water column as well as mussel tissue) at the Hurricane Barrier and control site. Day three samples were not analyzed for SFG after the first exposure period. There were no significant mortalities within or among stations during this exposure period.

There were no significant differences among stations in SFG or shell growth during the second deployment period in September. By day twenty eight there was a pattern of lowest SFG values at the Coggeshall Street Bridge, similar to the first pre-operational study, however, there were no statistically significant differences among stations. Water column chemical analyses during the third and fourth pre-operational study showed that chemical concentrations were the same as those observed during the first and second chemical analytical exercises. It is possible that reduction in SFG demonstrated during the first deployment reflects a combination of stresses including temperature as well as chemical stressors.

Again, there were no significant mortalities within or among stations during this exposure period.

Mussel Tissue Residue

During both periods of exposure, uptake of total PCB's was very rapid. After 7 and 28 days of exposure, total PCB values were comparable for similar time intervals between the two periods reaching slightly greater than 100 and 200 fold increases respectively over day 0 values at station 2 for example. After three days of exposure, levels concentrated by mussels at station 2 during the second exposure period were significantly higher than during the first. The uptake of total PCB's during the first three day exposure period was roughly a 30 fold increase over time 0 values while for the same period of exposure at time 2, the increase was roughly 100 fold. Because of the extraordinarily rapid rate of uptake during the first three days, the use of TOTAL PCB's may not be a good early warning measure for use in the Decision Criteria since a difference of only a few hours deployment time between "three day" exposure periods may result in very significant differences in results due to the extraordinary rate of uptake during this short time period.

An examination of Aroclor 1242 and Aroclor 1254 separately indicate that mussels in the harbor proper accumulate relatively higher levels of Aroclor 1242. The converse is true for mussels at the two reference sites located outside of the harbor proper and well out in Buzzards Bay. There is a significant increase in the ratio of Aroclor 1242 to 1254 as one progresses from the Hurricane Barrier up to Stations 3 and 2. There is roughly three times more Aroclor 1242 than 1254 at Station 2 compared to less than two times 1242 to 1254

at the Hurricane Barrier.

An examination of the individual congeners shows that the lower molecular weight congeners are taken up much more rapidly than the higher molecular weight congeners. Due to the less rapid uptake of congeners in the " mid-level" molecular weight range (i.e. CB128 and CB180) these congeners may be useful as the three day indicators of bioaccumulation for the purposes of the Decision Criteria.

CHEMICAL MEASUREMENTS

Polychlorinated Biphenyls

The temporal mean values for PCB concentrations are shown in Table 7. These means were based on the data for each sampling date (Palmquist, Sept. 1987; Dec. 1987). There is a distinct trend showing the highest concentrations at Station 1. Stations 2 and 3 exhibit intermediate and similar values.

The analyses of the dissolved and particulate phases of the samples at stations 1, 2, and 3 generally showed that the concentrations were higher in the dissolved phase than in the particulate phase for Aroclor 1242 (A1242). For Aroclor 1254 (A1254) the levels were similar in both phases. The concentrations of A1242 were higher than those of A1254 at Stations 1, 2, and 3. At Station 4 the concentrations of these two formulations were similar.

The spatial heterogeneity sampling in September (Palmquist Dec. 1987), showed that A 1242 was most concentrated in the surface water samples on both the east and west, Station 2 locations. Composite samples collected each hour were also analyzed to examine temporal heterogeneity. There was a significant trend in the distribution of total PCBs, pri-

marily reflecting the high proportion of A 1242. PCB concentrations appear to increase as the tide ebbed to slack low tide and decrease as the flood tide approached slack high tide. These data and those provided in Table definitely indicated the source of PCBs in the water column to be in the upper harbor.

Metals: Cadmium, Lead, Copper

Mean concentrations for the metals, Cd, Pb and Cu are also shown in Table 7. There are no consistent trends or differences in concentrations of any metal for the ebb and flood samples. Likewise, no station differences are evident except that Station 4 consistently showed the lowest concentrations. One other exception is that Cu concentrations were usually highest at Station 3.

Analysis of the particulate and dissolved phases for each metal showed that Cd was predominantly in the dissolved phase and that Cu was equally distributed between each phase. Interestingly, Pb concentrations were approximately equal in each phase during the dry period sampling but were at least twofold higher in the particulate phase during the wet period sampling. These data may reflect the input of Pb-associated particulates characteristic of urban surface runoff.

There were no trends in the data examining spatial heterogeneity at Station 2. In the temporal heterogeneity sampling, Cd showed the same hourly differences as was seen for PCBs, in that lowest concentrations were found near slack high tide and highest concentrations near slack low tide. the upper harbor and at or near Station 3 (Table 7), respectively.

DECISION CRITERIA

BACKGROUND

Decision criteria cannot be based on the enforcement of existing state or Federal water quality standards for PCB's because concentrations in harbor water currently exceed standards even in the absence of dredging. In addition, decision criteria cannot be based on the accumulation of biologically available PCB concentrations to the 2 ug/g FDA action level for seafood because PCB concentrations in indigenous organisms presently exceed this level. Decision criteria based on detection of toxicity in site waters or sediments are not practical, because sediments and water are toxic in the absence of dredging.

As described above, pre-operational monitoring data sets provide baseline levels of the variability of contaminant concentrations, toxicity, and bioaccumulation. This data allows the determination of sample intensity or design modifications to improve precision of data prior to operational phases. Once the operational phases begin, collection of identical data sets will allow discrimination of statistically significant increases in contaminants, toxicity, or bioaccumulation. The relevance of the magnitude of the increases above pre-operational phases is discussed below in "Numerical Criteria". If the increase is above the numerical criterion, the operation will be halted and the rate of return to pre-dredging conditions will be monitored. Providing that the return to pre-dredging conditions is acceptably rapid, the operation can recommence. This procedure will be used during each operational phase. If conditions produced by an operation are unacceptable in both magnitude and duration, additional engineering solutions will be required before operations can

begin anew.

NUMERICAL CRITERIA

Arbacia Sperm Cell Test - criteria under development

Red Algal Reproduction - criteria under development

Cyprinodon Growth and Survival - criteria under development

Mysid Growth and Reproduction - criteria under development

Suspended Solids - criteria developed, to be presented at meeting

PCBs and Metals

The data generated in Table 2 allow the calculation of a PCB or metal concentration that would be considered significantly higher at the $p > 0.05$. In all but three of the 16 cases, the criterion to mean ratio is below 2.0 and all values fall below 2.5. These data suggest that a decision criteria value of 2.5 would be a conservative estimate of those data which would be considered significant. Although the environmental significance of a statistical criterion is unknown, the small scale of this project and the relatively low contaminant concentrations, as compared to a full-scale "hot spot" remediation, would cause one to err on the conservative side.

Mussel Scope for Growth

The relative decrease in SFG values at the upper two stations as compared to the Hurricane Barrier and/or reference site, after three (or seven) days exposure, which would demonstrate "short term" chronic effects due to dredging during operational phases would be 50%. This value is derived from the variability and demonstrated sensitivity of SFG during the first deployment.

Relative reductions in shell growth at the upper two stations as

compared to Hurricane Barrier and/or reference site, after twenty eight days which would demonstrate negative effects from possible "long term" chronic effects due to operational dredging activities would be 50%.

This value is derived from variability and demonstrated sensitivity of shell growth during the first deployment.

Mussel Tissue Residue

Because of the rapid uptake of total PCB's in mussel tissue during the first three days of exposure, use of TOTAL PCB's at day three may not be appropriate as an early warning signal of increased availability that may result from dredging operations.

There are two alternatives;

1. Go to the seven day exposure period where the slope of the uptake curve has moderated considerably, or
2. Use the CB128 and CB180 congeners which are bioaccumulated at a much lower rate during the first days of deployment for this early warning purpose.

Based on the bioaccumulation of the measured chemicals (PCB's, metals) during the two pre-operational exposure periods, it would be necessary for an increase of ~~14,461~~ and ~~14,372~~^{ng}/g in mussel tissue in order to see a significant pulse from the operational phases after seven and twenty eight days of exposure, respectively.

The recommended limit of a two fold increase in the tissue concentrations, as stated in the Decision Criteria, is supported (or modified).

DECISION MATRIX

I. Characterize predredging conditions (See Results section)

II. Characterize conditions during construction of the CDF dike, dredging with disposal in the CDF, dredging with disposal in the CAD cell, down time during dredging activities, and post operational phases. During each of these phases and during the use of each type of dredge, monitoring activities will characterize site conditions using the methods described in Otis Section 3. Site conditions, during each of these operational phases, will be statistically compared with predredging conditions.

III. Decision Criteria

If no statistically significant increase is detected in data from any of the monitoring activities, the project will continue. To insure that pre-operational conditions are representative for the site, conditions between operational activities will also be monitored and statistically compared with pre-operational and operational phases to insure that no increase has occurred.

If a statistically significant impact is detected that is above the numerical criteria for any operational phase in monitoring data from the Coggeshall Street Bridge, that phase will be stopped and the rate of return to pre-operational conditions will be monitored.

If the conditions rapidly return to those of the pre-operational phase, the operation can be continued. After the operation resumes, additional monitoring is required to confirm that any further impact is minimal and that the rate of return to "normal" is consistent with known

flushing rates of the Acushnet River.

If conditions fail to return to those of the pre-operational phase, an engineering solution to limit impacts must be instituted such as those discussed in Otis (1987) Section 2.7. If conditions fail to rapidly return to those during the pre-operational phase following implementation of engineering solutions, it is possible that pre-operational monitoring did not adequately characterize background conditions during the actual time of operation. For this reason, it may be desirable to resume the operation with planned shutdown times to demonstrate that inter-operational monitoring does not result in continued increases in detectable impacts. Finally, if data from environmental monitoring demonstrates that the above conditions cannot be met and that long-term, far-field impacts are likely to result from continued operations, then the project will be stopped.

Representatives from appropriate Federal and state agencies will form a group that will be responsible for reviewing the monitoring data as it becomes available. After reviewing these data, the group would make decisions as to the daily operations during the pilot study.

IMPLEMENTATION

Data Flow and Decision Points

The following outline of sample collection, data generation and decision points describe the events which will occur during any seven-day sampling effort. This time interval occurs several times during the operational phases of the Pilot Study. At each decision point, the advisory group would convene to review the data sets and consider the following options.

A. Decision criteria violated by data sets:

1. Discontinue operation?
2. Discontinue sample collection for seven day static renewal bioassay?
3. Continue 24 hour sampling regimen until toxicity and chemical pulse drop to levels acceptable according to the criteria?
4. Consider amplitude (time vs. intensity) of chemical/toxicity pulse.
5. Consider containment strategies?
6. Re-initiate operation?

B. No violation of decision criteria

Continue operations and sampling, flood and ebb tide composite samples for seven day static renewal bioassays and 24 hour sample regimen.

SCHEDULE

Day 1: Commence water collections and begin analysis of 24 hour data sets
(suspended solids, PCBs, SCT)

Day 2: Continue water collections for two day algae test, seven day
mysid and fish receiving water tests

* Decision Point - review 24 hour data

Day 3: Continue water collections for seven day receiving water and 24
hour data sets, collect mussels for 3 day SFG and tissue residue,
begin recovery period for two day algae test

Day 4: Continue water collections for seven day receiving water tests, complete
24 hour and mussel SFG analysis

* Decision Point - review 24 hour and mussel SFG data set

Day 5: Continue water collection of seven day and 24 hour data sets,
complete mussel tissue residue analysis

* Decision Point - review 24 data set

Day 6: Continue water collection for seven day receiving water tests, complete 24 hour analysis

Day 7: Complete water collection for seven day and 24 hour data sets, collect mussels for SFG and tissue residue analysis

Day 8: Complete seven day tests, 24 hour analysis, mussel SFG, 2-day test recovery period

* Decision Point: review 24 hour and mussel SFG data sets

Day 9: Complete seven day receiving water tests analysis, mussel tissue residue analysis and two day test analysis

* Decision Point: review seven day, mussel tissue residue and

* Decision Point - review mussel tissue residue data set two day data sets.

ISSUES

1. Greater resolution of the turbidity field both spatially and over time. Using the present composite sampling scheme, water from the bottom, mid and upper water column is pooled for total suspended solids (TSS) data. While this approach appears satisfactory during pre-operational phases when steady-state conditions exist, it may prove inadequate during disturbance events. Pulses of material may flow at specific depths or be differentially concentrated across the stream. Thus, greater emphasis should be made to characterize the spatial and temporal turbidity field under the Coggeshall St. Bridge during operational phases.

2. Temporal variability of the turbidity field. Under the current sampling scheme, sampling at hourly intervals during both ebb and flood tides over two of seven days is an intensive effort to assess spatial

variability in contaminant transport. This effort does not take into account the possibility that significant pulses of material may flow out of the upper harbor between sampling periods or on days when TSS data is not collected. A monitoring effort should be in place to account for such events. Currently, only biological monitors are being used to address this question.

These data needs could be easily accomplished through the use of the laboratory transmissometer connected to CTD (conductivity-temperature-depth) instrument. Vertical casts of the CTD package within a sampling grid of appropriate scale would address items 1 and 2 above. The temporal variability question could be addressed by stationary deployment at 1m above bottom within the channel.

3. Since the application of the decision criteria requires a statistical evaluation, the issue of sample replication is an important one. It is recommended that, during the fifth and final pre-operational sampling, replicate samples be taken for chemical and suspended sediment analyses. These replicates should consist of ebb or flood composites for chemical analyses and mid-tide, hourly composites for suspended solids measurements. Samples should be collected from at least two stations, possibly Stations 3 and 4.

4. Given the existence of a temporal gradient in PCB and Cd concentrations at Station 2, the creation of temporally composited samples at this station must be given serious consideration. Under natural conditions, the temporal effects would likely average out but to see a pulse that is not tidally induced will require flow proportional temporal composites.

5. Day three SFG analyses should be repeated during the operational phase since the second pre-operational exposure, the first time that three day SFG analyses were attempted showed no differences among stations independent of the length of exposure.

6. Regression analysis similar to that run for PCB tissue levels and shell growth should be repeated for SFG values, and metal values when the data are available.

7. What data are available for presentation to support the statements that "mussels were at the peak of the reproductive cycle."?

8. On the basis of these initial data sets, can we reduce the number of replicates used?

9. When the three-day or seven day question as outlined above is resolved, should one or the other sampling dates be eliminated. The three day measure has significance related to SFG, and the seven day to the short term chronic test with mysids and fish as well as to SFG.

10. Do we need to continue both three and seven day SFG measures?

11. The Champia test requires further development for better quality control.

12. The Laminaria test requires resolution of problem of variability among replicates.

13. *Used for final preoperational*

Table 1. Pre-operationnal water column analyses.

SAMPLE DATE	<u>Cyprinodon</u>	<u>Mysidopsis</u>	<u>Arbacia</u>	<u>Champia</u>	<u>Laminaria</u>	Suspended Solids	Chemical
07/08	X	X	X	X	X	X	X
07/09	X	X	X			X	
07/10	X	X					
07/11	X	X					
07/12	X	X	X	X			
07/13	X	X	X				
07/14	X	X	X	X		X [*]	X [*]
09/22	X		X	X			
09/23	X						
09/24	X		X*	X	X	X	X
09/25	X						
09/26	X						
09/27	X		X				
09/28	X		X*	X	X	X	X

* indicates tests performed on both individual and composite water samples.

Table 2. New Bedford Weather Observations

The following weather observations were collected by the City of New Bedford Department of Public Works and provided by Mr. Leon Halle, Supervising Civil Engineer.

JULY					
TEMP					
	MAX	MIN	0800		PRECIP.
1	86	66	66		
2	77	63	68	RAIN	.52"
3	78	60	61	RAIN/DRIZZLE	.12"
4	82	66	67	DRIZZLE/FOG	Trace
5	82	64	71		
6	80	61	68	CLEAR	
7	76	58	62	CLEAR	
8	73	64	66	CLOUDY	
9	87	66	69	AM FOG/CLDY/HAZY	
10	90	68	78	AM FOG/CLR/HAZY	
11	82	68	70	AM FOG/HAZY	
12	75	68	70	AM FOG/OVERCAST	
13	74	68	68	RAIN/DRIZZLE	.01"
14	77	70	72	FOG/SHOWERS/TS	Trace
MONTH TOTAL					1.13"

SAMPLING PERIOD

SEPTEMBER					
TEMP					
	MAX	MIN	0800		PRECIP.
13	70	64	65	HEAVY RAIN	1.26"
14	81	64	70	RAIN	.16"
15	79	56	58		
16	80	60	61		
17	76	65	68	RAIN	.23"
18	65	55	60	SHOWERS	.28"
19	59	56	56	SHOWERS	.72"
20	61	55	58	RAIN	1.36"
21	63	54	54	MIST	.03"
22	72	57	58	CLOUDY	
23	72	54	54	CLDY/CLR	
24	77	58	58	CLR/CLDY/RAIN	.03"
25	67	49	50	CLEAR	
26	68	46	49	CLEAR	
27	68	49	49	CLEAR	
28	73	55	61	CLEAR	
MONTH TOTAL					5.49"

SAMPLING PERIOD

Table ³ 4. Mean ebb and flood suspended solids concentrations at four stations in New Bedford Harbor during July and September, 1987. N = 5 for all means unless otherwise noted.

STATION	DATE	CONCENTRATION (mg/l)	
		MEAN + SD	
		EBB	FLOOD
1	7/8	5.6 ± 1.8	8.4 ± 1.9 (4)
	7/9	6.1 ± 1.3	7.6 ± 1.6
	9/24	8.6 ± 0.8	7.8 ± 1.1 (4)
	9/28	6.5 ± 0.8	6.5 ± 2.0
		6.7 ± 1.3 7.0 (4)	7.0 ± 2.0 10.0 (4)
2	7/8	7.9 ± 1.9 (4)	10.2 ± 1.7
	7/9	7.8 ± 0.8	9.4 ± 1.1
	7/13	8.3 ± 1.3	7.4 ± 1.0
	9/24	7.5 ± 1.1	6.8 ± 1.1 (4)
	9/28	6.4 ± 0.4	7.0 ± 2.0
		7.0 ± 2.7 9.2 (5)	8.2 ± 1.5 11.2 (5)
3	7/8	10.1 ± 2.0	11.4 ± 4.5
	7/9	8.9 ± 1.3	15.0 ± 6.4
	9/24	8.2 ± 0.9	9.4 ± 4.3
	9/28	6.1 ± 1.0	6.5 ± 1.0
4	7/8	5.4 ± 1.6	6.6 ± 1.9
	7/9	5.5 ± 0.8 (4)	7.1 ± 1.0
	9/24	7.9 ± 1.5	7.8 ± 3.4
	9/28	4.4 ± 1.2	7.1 ± 1.3

4
Table 2. Results of New Bedford Harbor receiving water evaluation using the sea urchin, Arbacia punctulata. Results are presented as percent fertilized on each day of testing. Controls included in the test are a Narragansett Bay control (NSW), an autoclaved Narragansett Bay control (ANSW), and a site control from Buzzard's Bay.

SITE/ TIDE	EFFECT, PERCENT FERTILIZED			
	09/23/87	09/25/87	09/28/87	09/29/87
CONTROL (NSW)	91.5 \pm 2.1	93.5 \pm 2.1	94.0 \pm 1.4	94.0 \pm 5.7
CONTROL (ANSW)	90.8 \pm 4.5	92.6 \pm 2.2	95.5 \pm 0.7	97.0 \pm 1.4
CONTROL (SITE)	64.9 \pm 17.7 a	92.0 \pm 2.9	95.0 \pm 1.4	93.5 \pm 0.7
EBB	81.7 \pm 5.9	94.0 \pm 1.4	94.0 \pm 1.4	94.5 \pm 0.7
1 FLOOD	56.5 \pm 23.4 a	93.0 \pm 1.5	93.0 \pm 1.4	96.5 \pm 0.7
2 EBB	65.4 \pm 9.7 a	92.5 \pm 3.6	94.0 \pm 4.2	94.5 \pm 2.1
2 FLOOD	81.6 \pm 5.8	90.0 \pm 1.5	94.5 \pm 0.7	93.5 \pm 2.1
3 EBB	95.9 \pm 0.6	92.5 \pm 0.7	94.5 \pm 2.1	95.0 \pm 1.4
3 FLOOD	74.6 \pm 7.6	94.0 \pm 1.4	93.0 \pm 1.4	95.0 \pm 2.8
4 EBB	90.7 \pm 0.1	93.1 \pm 2.6	94.0 \pm 4.2	95.2 \pm 4.3
4 FLOOD	92.6 \pm 4.8	95.0 \pm 1.4	93.5 \pm 2.1	96.5 \pm 0.7

a) Significantly lower than the lab and test controls.

Table 6. The effect of receiving waters from New Bedford Harbor on the sexual reproduction of Champia parvula. Results are expressed as the mean number of cystocarps formed per plant. Samples were collected on September 24 and 28, 1987, and the tests begun the following day. Temperature was 22 to 24 C, salinity was 30 parts per thousand, and light density was ca 75-100 $\mu\text{E m}^{-2} \text{ s}^{-1}$ of cool-white fluorescent light on a 16:8 L:D cycle.

Site/ Tide	No. of Cystocarps + S.D.	
	9/24	9/28
Control (Site)	12 \pm 4	10 \pm 1
1 Ebb	6 \pm 2	4 \pm 1
1 Flood	4 \pm 3 a	4 \pm 1
2 Ebb	4 \pm 4 a	3 \pm 1 a
2 Flood	5 \pm 3	5 \pm 5
3 Ebb	8 \pm 3	4 \pm 2
3 Flood	dead	0 \pm 0 a
4 Ebb	6 \pm 5	5 \pm 3
4 Flood	3 \pm 5 a	6 \pm 7

a) Statistically different from the site control.

able 4. The effect of receiving waters from New Bedford Harbor on the sexual reproduction of Laminaria saccharina. Results are expressed as mean number of sporophytes formed per plant. Samples were collected on July 8, 1987 and the test started on July 9. Temperature was 14 to 16 °C, salinity was 30 parts per thousand, and light density was ca 50 $\mu\text{E m}^{-2} \text{ s}^{-1}$ of cool-white fluorescent light on a 16:8 L:D cycle. Recovery was under red fluorescent light.

Site/ Tide	No. of Sporophytes/plant \pm S.D.
Control (Narragansett)	76 \pm 6 a
Control (Site)	124 \pm 18
1 Ebb	99 \pm 14 a
1 Flood	107 \pm 15
2 Ebb	155 \pm 14
2 Flood	88 \pm 12 a
3 Ebb	106 \pm 16
3 Flood	125 \pm 16
4 Ebb	103 \pm 12
4 Flood	148 \pm 11

a) Statistically different from the site control.

Table 2. Whole water concentrations of PCBs, Cd, Pb and Cu measured on samples collected at four stations in New Bedford Harbor in July and September, 1987. Means and standard deviations are based on values for each date for ebb and flood tidal conditions. N=4 unless otherwise noted.

STATION/TIDE	CONCENTRATION (ug/l)			
	PCB	Cd	Pb	Cu
1 E	1.147 \pm 0.560	0.22 \pm 0.10	4.0 \pm 0.2	7.8 \pm 3.6
F	1.009 \pm 0.353	0.29 \pm 0.06	3.9 \pm 0.4	8.0 \pm 1.8
2 E	0.607 \pm 0.099 (5)	0.20 \pm 0.04	3.4 \pm 0.3	6.5 \pm 1.0
F	0.531 \pm 0.130 (5)	0.13 \pm 0.02	3.1 \pm 1.2	8.5 \pm 1.1
3 E	0.578 \pm 0.113 (3)	0.22 \pm 0.06	3.5 \pm 0.8	9.4 \pm 2.7
F	0.405 \pm 0.188	0.24 \pm 0.10	2.7 \pm 0.4	9.1 \pm 0.8
4 E	0.114 \pm 0.013	0.11 \pm 0.05	2.3 \pm 1.1	2.9 \pm 0.9
F	0.106 \pm 0.009	0.14 \pm 0.06	1.8 \pm 0.9	2.5 \pm 1.0

§
 Table 3. Comparison of observed mean concentrations (ug/l), significantly elevated values (CRIT) and their ratios for PCB, Cd, Pb, and Cu at Stations 2 and 3 in New Bedford Harbor.

Station		EBB			FLOOD		
		OBS.X	CRIT.	RATIO	OBS.X	CRIT.	RATIO
2	PCB	0.607	0.838	1.38	0.531	0.835	1.57
	Cd	0.20	0.31	1.55	0.13	0.18	1.38
	Pb	3.4	4.2	1.24	3.1	6.3	2.03
	Cu	6.5	9.1	1.40	8.5	11.4	1.34
3	PCB	0.588	0.959	1.63	0.405	0.900	2.22
	Cd	0.22	0.38	1.73	0.24	0.50	2.08
	Pb	3.5	5.6	1.60	2.7	3.8	1.41
	Cu	9.4	16.5	1.76	9.1	11.2	1.23

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Environmental Research Laboratory
South Ferry Road
Narragansett, R.I. 02882

DATE: May 24, 1988

TO: Distribution

FROM: Skip Nelson *SN*

SUBJECT: Water sampling design at Coggeshall St. Bridge

Water samples will be collected at the Coggeshall St. Bridge on May 25 to determine whether ERL-N's sampling design (2 locations at the bridge) is statistically different from that used by the COE in the past (3 locations at the bridge). The COE has "suggested" that our mean PCB values at NBH-2 are lower than theirs due in part to the fact that our sampling locations do not include the center of the channel under the bridge. Hopefully this exercise will answer this question.

The sampling design used to constitute the ERL-N samples includes collecting water at three depths at the east and west side of the bridge (6 all together), and flow-proportionally compositing them to produce one composite sample each hour. This will be repeated at five hourly intervals over a tidal cycle. The COE sampling design will include collecting separate samples (at three depths) at the east and west sides of the bridge as well as at the center (9 samples in all). These samples will also be flow-proportionally composited at hourly intervals for five hours over a tidal cycle. Total PCB's will be measured in the 5 composite samples from each sampling design. The data from each sampling design will be compared using a t-test to determine whether differences in sampling design result in statistically different mean PCB values in water samples collected at NBH-2.

cc:

John Scott
Don Phelps
Dave Hansen
Bruce Reynolds
Greg Tracey
Walt Galloway
Rich Pruett

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Environmental Research Laboratory
South Ferry Road
Narragansett, R.I. 02882

DATE: June 13, 1988

TO: Distribution

FROM: Skip Nelson *SN*

SUBJECT: Results of water sampling design at Coggeshall St. Bridge

On May 25 water samples were collected at the Coggeshall St. Bridge according to 2 different sampling designs to determine whether the sampling procedures employed by ERL-N were comparable to those used by the COE.

The ERL-N sampling design included collecting water at three depths at the east and west side of the bridge (6 all together), and flow-proportionally compositing them to produce one composite sample each hour. The COE sampling design included collecting separate samples (at three depths) at the east and west sides of the bridge as well as at the center (9 samples in all) and flow-proportionally compositing them each hour. This was repeated at five hourly intervals over a tidal cycle.

Total PCB's were measured in the 5 composite samples from each sampling design. In addition, the sperm cell assay was used to test the toxicity of each composite sample. The means and standard deviations are listed below.

Sampling Design	Total PCB	Sperm Cell Fertilization (%)
EPA	0.63 (0.18)	86 (2)
COE	0.57 (0.17)	81 (9)

A t-test on each parameter indicated no significant difference due to sampling design between the mean PCB concentrations ($t=0.61$, $P=0.56$) or the mean sperm cell fertilization values ($t=1.24$, $P=0.28$). These data indicate that the two sampling procedures provide comparable results and that past differences between COE PCB concentrations and those generated by ERL-N may have been due to analytical differences rather than sampling design. Based on these data, the ERL-N sampling procedures will be used throughout the rest of the Pilot Project.

cc:

John Scott
Don Phelps
Dave Hansen
Bruce Reynolds
Greg Tracey
Walt Galloway
L. Pruell